A camera based system for contactless pulse oximetry

Christian Schiffer[(1)], Andreas R. Diewald[(1)], and Rene Thull[(1)]

[(1)] Laboratorey of applied Radar Technology and Optical Systems (LaROS),
Department of Electrical Engineering, Trier University of Applied Sciences,
D-54293 Trier, Germany

E-Mail: c.schiffer@hochschule-trier.de
Web: www.hochschule-trier.de/go/laros

Abstract – The arterial pulse rate and the arterial oxygen saturation (SaO2) are an important part of monitoring a patient's vital signs. To estimate a patient's SaO2 value conventional probes need to be attached to the subject's skin, in most cases around a finger or, in the case of premature infants, around a foot. This method is not always suitable, as there are reasons like damaged skin tissue or frequent loosening of the sensor, which prohibit attaching a probe directly.
With the methods presented here a camera based system can be used, that allows contactless measurements of the beforementioned vital signs. The system consists of a camera attached to a time multiplexed LED-array alternating red (660nm), near-infrared (810mn) and no active illumination synchronously during the exposure for each recorded image. The camera sensor's 10-bit ADC capability is barely sufficient for detecting arterial pulse related changes of brightness on an observed area of skin. Hence the ADC's sensitivity is extended by integrating brightness values over two areas of interest (64x64 pixels).

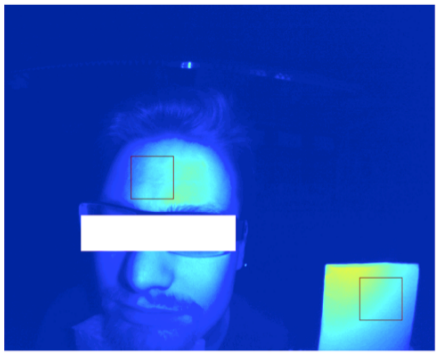
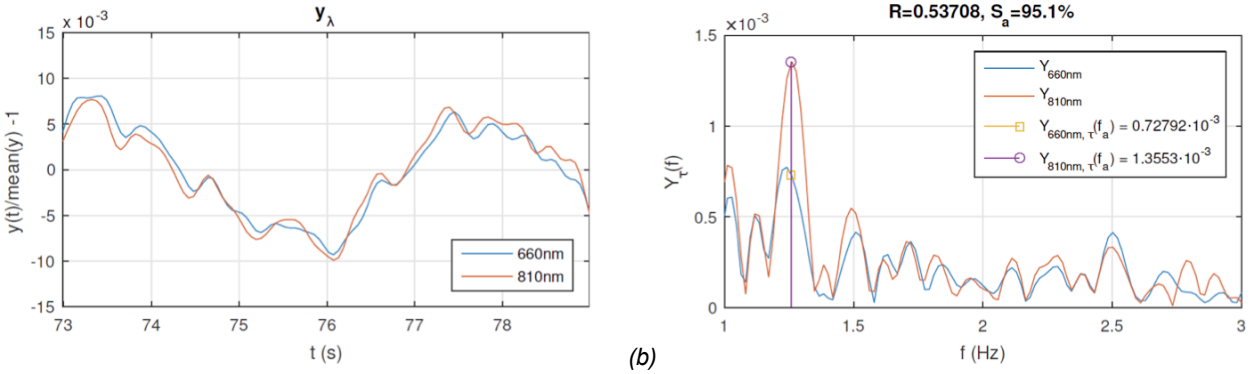


Fig. 1: Recorded picture with the red squares marking the areas of interest.

Those areas of interest record an area of the subject's skin and a lifeless reference area, that is used to cancel the effects of an unstable lighting due to changes of the LEDs' luminosity. This theoretically allows the camera to detect changes of 2^{-22} in the luminosity value of the camera. By carefully choosing the sampling rate the camera's limitations fulfilling the sampling theorem for background noise sources can be minimized. After transforming the pre-processed signals into frequency domain, the subject's arterial pulse rate can be determined.



(a) *(b)*

Fig. 2: The recorded signals in time-domain (a) and in frequency-domain (b).

The frequency-domain-signal contains information about the absorbance of light by pulsating arterial vessels corresponding to each utilized wavelength of light. This information can then be used to calculate the arterial oxygen saturation by approximating the Beer-Lambert law as demonstrated in figure 2.

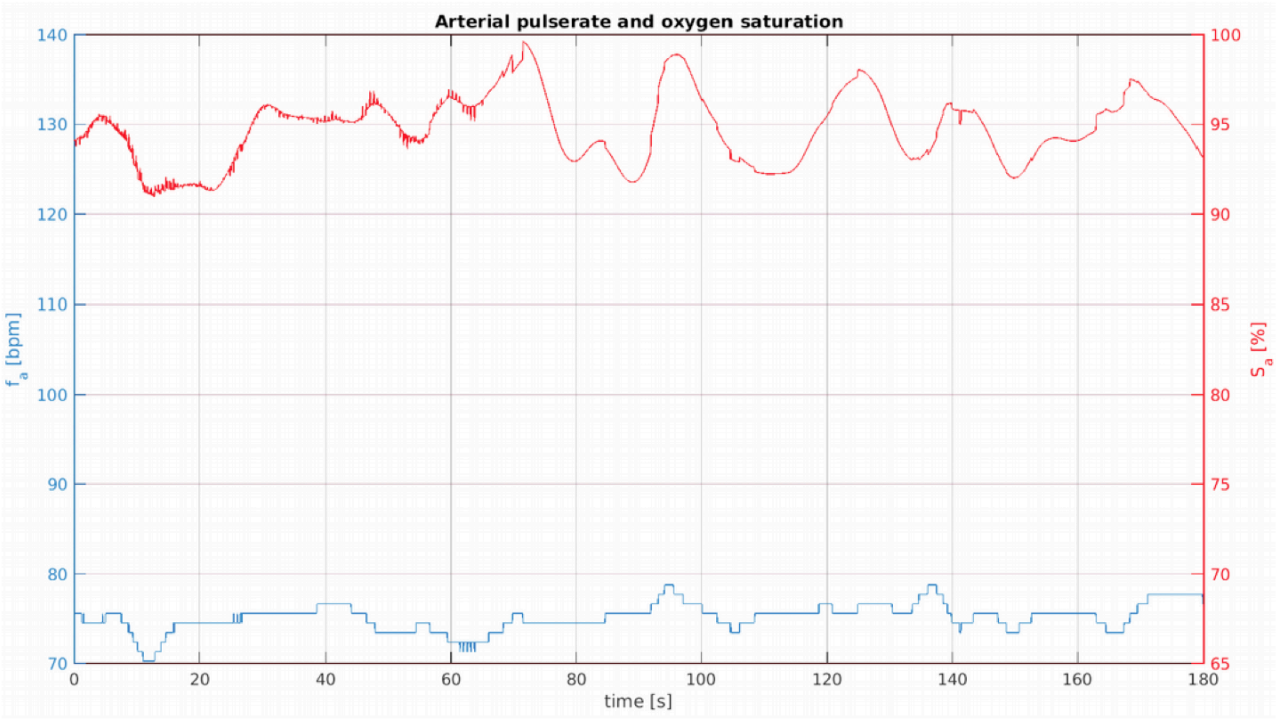


Fig. 3: Resulting arterial pulse (blue) and arterial oxygen saturation (red).

While improvements like enhanced signal analysis, using more sampling rates or face detecting and tracking remain to be implemented, measurements of the arterial pulse rate and oxygen saturation demonstrate this camera based system as a promising basis for a camera based pulse oximetry system.